CNTT-E-110

BASIC ELECTRICITY AND

ELECTRONICS

STUDENT HANDOUT

NO. 203

SUMMARIES
PROGRESS CHECKS
FOR
MODULES

21 LESSONS 2,3,&4

JUNE 1984

SUMMARY
LESSON II

Transistor Biasing

Static Bias is defined as the DC potentials at the collector and the base with respect to the emitter necessary to establish a transistor's conduction level.

The transistor's emitter is always used as the reference point. In an NPN transistor biased for conduction, the base will be more positive than the emitter, and the collector will be more positive than the base and the emitter. In a PNP transistor biased for conduction, the base will be more negative than the emitter, and the collector will be more negative than the base and emitter. This is shown in Figure 1.

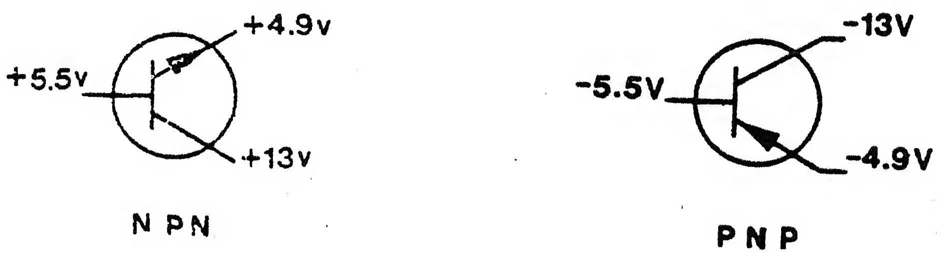


Figure 1

The voltages shown on the transistors' leads in Figure 1 were measured with respect to ground. To find the actual static bias voltages across the transistor's elements you must:

1. Subtract the emitter voltage from the base voltage for the base-emitter static bias voltage (Vbe).
2. Subtract the emitter voltage from the collector voltage for the collector-emitter static bias voltage (Vce).

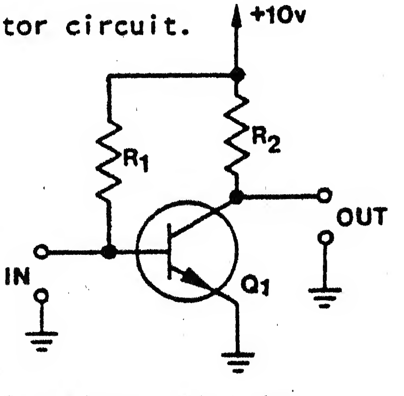
The flow of current in a transistor will be against the arrow, as shown in Figure 2.

Current Flow in NPN and PNP Transistors

Figure 2

As you can see from Figure 2, no current flows between base and collector. The emitter current in both transistor types is a combination of both the base and collector currents.

Figure 3 shows an NPN transistor circuit.



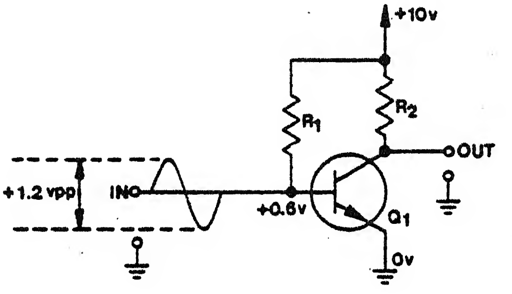
NPN Transistor Circuit

Figure 3

The voltage applied to the collector comes from the +10 volt supply through R2.

The base-emitter bias voltage is produced by the current flow from ground through the base-emitter, through R1, to the +10 volt supply. The base-emitter has a certain resistance which will produce a voltage drop across it. The amount of voltage will be determined by the amount of current R1 allows to flow in the base-emitter circuit. Changing R1's value changes the amount of current that flows in the base-emitter circuit giving us an easy way of changing base-emitter static bias voltage (Vbe).

The transistor's base is its controlling element. Changing the base-emitter circuit current, by changing the voltage applied to the base-emitter, will cause a change in transistor conduction. Because of transistor construction it only takes a few tenths of a volt across the base-emitter to make a large change in conduction in the collector-emitter circuit. See Figure 4.



NPN Transistor Circuit with Input Signal

Figure 4

A 1.2 volt peak-to-peak sine wave is applied to the base which, in this case, has a 0.6 volt D.C. static bias voltage on it. The sine wave will add to and subtract from the 0.6 volt DC static bias voltage causing the base voltage to vary between 0.0 volts and 1.2 volts, as shown in Figure 5.

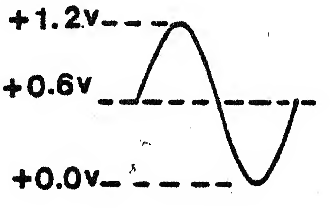


Figure 5

The changing potential caused by the input signal is called Dynamic Bias. Dynamic bias is the bias voltage on the base of a transistor with a signal applied and is a combination of the input signal and the static bias voltage.

A sine wave will cause maximum conduction in a NPN transistor during its positive variation and minimum conduction during its negative variation. In a PNP transistor a sine wave will cause maximum conduction during its negative variation and minimum conduction during its positive variation. The increase in conduction causes a decrease in the voltage across the transistor. Since voltage is what is seen on an oscilloscope, you will see a positive-going input as an amplified negative-going output. The sine wave's negative variation will show an amplified positive-going output. This is shown in Figure 6.

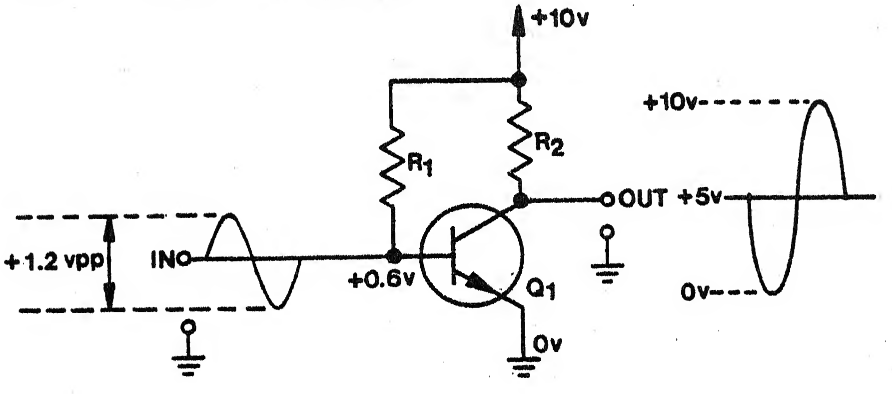


Figure 6

PNP transistors work the same. A positive-going input produces an amplified negative-going output.

The potential for the collector is called Vcc or collector supply voltage. Regardless of the amount of amplification, the peak-to-peak output voltage cannot exceed the value of Vcc.

Heat can easily destroy a transistor. For this reason transistorized equipment is normally located in air conditioned spaces. However, a transistor can create its own internal heat which can destroy it even though it may be in an equipment which is located in an air conditioned space.

In the fixed base bias circuit, Figure 7, the only control over static base-emitter current is the resistance of the base-emitter and R1's resistance.

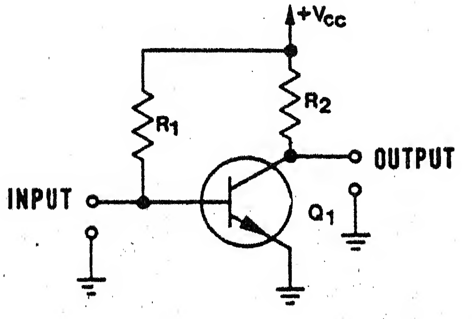
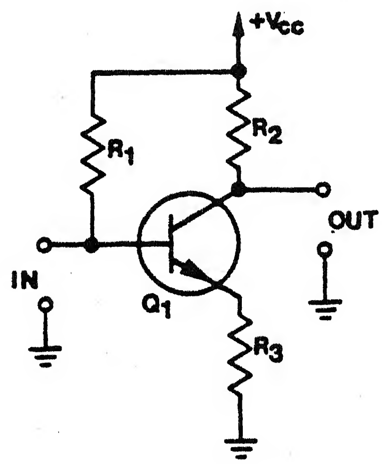


Figure 7

R1's resistance is fixed and will not change. However, Q1's base-emitter resistance will decrease if a certain temperature limit is exceeded. If the base-emitter resistance begins to decrease, more current will flow through the base-emitter increasing collector-emitter current flow. As the collector-emitter current flow increases it causes more internal heating of the transistor. The extra heat increases base-emitter current which increases collector-emitter current again producing more heat. Once started, this process, called thermal runaway, continues until the transistor destroys itself. Thermal runaway can be prevented by the addition of a stabilizing resistor, called an emitter resistor, between a transistor's emitter and ground as shown in Figure 8

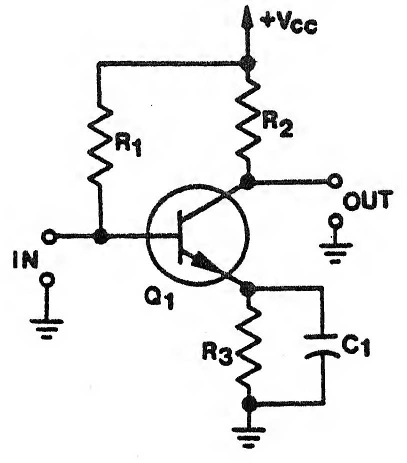


NPN Transistor Circuit with Emitter Resistor

Figure 8

Emitter resistor R3 has a large resistance as compared to the resistance of the base-emitter. Now, the base-emitter resistance is only a small percentage of the total base-emitter circuit resistance. If base-emitter resistance decreases from heat there will be practically no change in base-emitter current flow.

However, the emitter resistor causes degeneration (reduced signal amplification) as the signal developed across it is in phase with the input signal reducing dynamic bias. To prevent degeneration, an emitter by-pass capacitor (C1 in Figure 9) is added to shunt (by-pass) the degenerating signal voltage to ground without effecting the static bias voltage.



NPN Transistor Circuit with Emitter Resistor and Emitter By-Pass Capacitor

Figure 9

There is one other cause of thermal runaway which does not always occur as it is dependent on circuit design and application.

In some circuits it is possible for the transistor's base to build up a charge, positive for NPN and negative for PNP. In either case, the charge increases the transistor's forward bias. An increase in forward bias increases transistor conduction producing internal heating. The extra heat will further increase the charge again increasing forward bias and producing more heat from conduction. This cycle continues and we again have thermal runaway. To prevent this type of thermal runaway a resistor is placed between the transistor's base and ground to bleed off the charge as it forms. The resistor is shown as R3 in Figure 10.

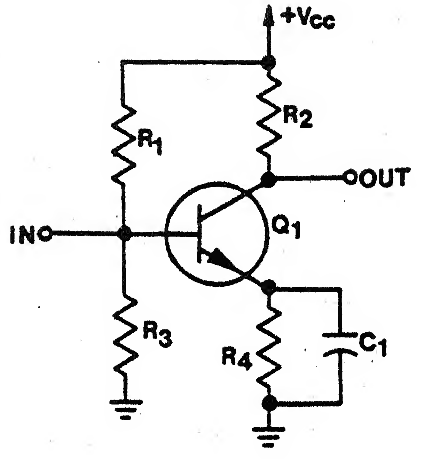


Figure 10

R3 will bleed off the charge that forms on Q1's base with very little effect on the base bias voltage, stabilizing the transistor.

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A-V RESPONSE SHEET
LESSON II

Transistor Biasing

NOTE: There may be more than one correct answer to the Question asked by the Audio Visual Film. Circle the Correct Response.

1.	A	B	C	D	E	F
2.	A	B	C	D		
3.	A	B	C	D		
4.	A	B	C	D		

JOB PROGRAM
FOR
LESSON II

Transistor Biasing

INTRODUCTION

In this job program you will see how temperature will affect the conduction of a transistor, and observe bias with an oscilloscope.

OBSERVE ALL STANDARD SAFETY PRECAUTIONS.

EQUIPMENT AND MATERIALS

1. Device 6F16
2. Template "A - Common Emitter Amplifier
3. Multimeter (1)
4. Oscilloscope (6B28)
5. 1X Probe (2)
6. Double Alligator Lead (1)

PROCEDURE

Turn on your oscilloscope so that it can warm up and stabilize while you proceed.

Open the 6F16 training device, being careful that the name plate is upright to ensure that the components won't spill out. Disconnect the base from the component storage half. Select the following components, and place the storage section out of your way.

Power Cord (1)

Template "A" (1)

2N217 Transistor (1)

10 µfd Capacitor (1)

Shorting Strips (sizes as required by template "A") (5)

2 Kohm Potentiometer (1)

2.2 Kohm Resistor (1)

18 Kohm Resistor (1)

Adjust the oscilloscope for a line trace according to standard set-up procedures. Set Sweep Time to .5 millisec/div.

Connect the 1X Probe to Channel "1" on the oscilloscope.

Lay template A "Common Emmitter Amplifier" squarely on 6F16 training device and align the holes.
Install four of the plug-in shorting wires marked SS from the components box in locations marked, "A", "B", "C", and "G"; transistor 2N217 in space so marked; an 18 kohm resistor in R2 position; and a 2.2 Kohm resistor in RL position. Place a 2 Kohm potentiometer in the space so marked, and adjust it all the way clockwise.
Connect a multimeter into position "D", connecting the red lead closest to the transistor. Set the meter to read current on the 10 ma scale.

Plug the 6F16 training device into an electrical outlet, and energize it.

Position the line trace of the oscilloscope with the top horizontal line on the CRT grid. Set the AC/DC switch to measure DC; volts/div at .02 volts/div.

Connect the 1X probe to the shorting strip in position B, the base of the transistor. Connect ground strap on probe to shorting strip "G".

Slowly rotate the 2 Kohm potentiometer counter-clockwise while watching the oscilloscope display.

1. In which direction did your line trace move? (+ or -)

2. Do you have collector current? (Yes/no)

3. Which type of transistor are you using? (NPN/PNP)

Next you will see what temperature will do to your equipment. Adjust the 2 Kohm potentiometer for a small indication of collector current. With your index finger and thumb hold the transistor cap firmly. Watch the collector current monitor meter closely. Place ammeter on 1ma scale for best results.

4. Did the meter reading increase or decrease? ______________________

The temperature from your body changed the conduction of this transistor.

Not all transistors are this sensitive, and there's not much difference between room temperature and your body temperature. If this circuit were designed for a certain amount of gain, you can see how temperature could cause it to fail. Therefore, transistorized equipment is usually designed to operate within specific temperature ranges.

Turn the 2 Kohm potentiometer clockwise.

Push the AC/DC switch on the oscilloscope to AC, and realign your line trace with the top horizontal line on the face of the CRT. Push the AC/DC switch back to DC. (Your line should be in the same position).

Rotate the 2 Kohm potentiometer fully counter-clockwise. Note the position of the line trace on the CRT. Adjust the 2 Kohm potentiometer for a line trace half way between the last position and the top horizontal line on the CRT (about .1 volts). You have just set the bias of the transistor for conduction at the center of its range.

Move the 1X probe from position B on the template to the collector side of resistor RL. Change the oscilloscope volts/div to 2 volts/div.

Push the AC/DC switch to AC, and readjust the line trace position to the top horizontal line on the CRT. Push the AC/DC switch back to DC. Record your voltage in the space provided.

5. Collector voltage ____________ volts. De-energize the 6F16 device.

Place the 10 μfd capacitor in the position indicated on the template (be sure to observe polarity), and place the last shorting strip in position "F".

Connect a 1X probe to the calibrator 1 KHz output volts on the back side of the oscilloscope. Attach the other end to the left side of the 10 μfd capacitor. This is the same as the AC input.

Connect ground strap on probe to shorting strip "G". (Use double alligator lead to extend probe ground strap in order to reach shorting strip "G".)

Set the calibrator switch to .2 volts p-p. Move the Channel 1 1X probe to the right side of RL. Energize the 6F16 device.

6. Record your output signal in the space provided. ____________ volts p-p.

7. De-energize the 6F16 device, replace all covers, and return equipment to it's stowage.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

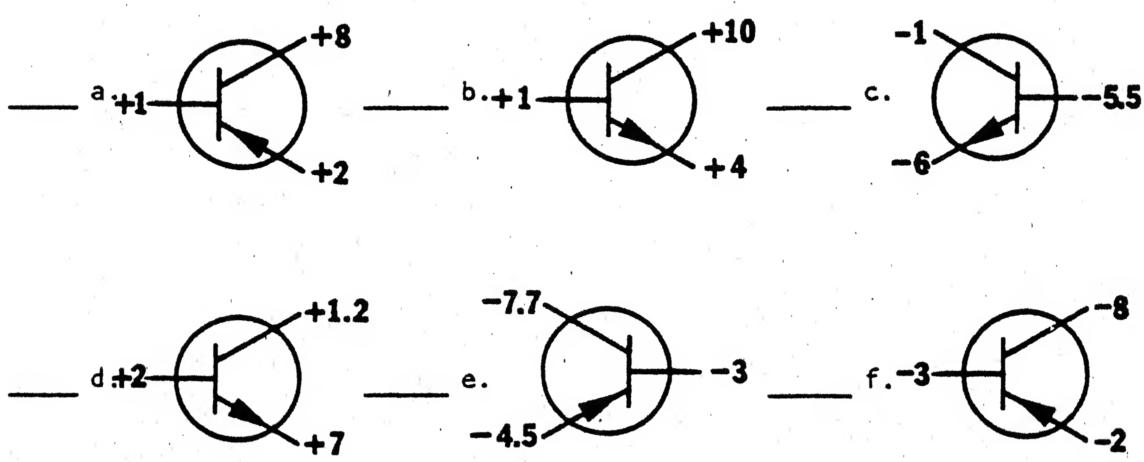
PROGRESS CHECK
LESSON II

Transistor Biasing

1. Static bias may be defined as the:

   a. D.C. potentials on the base and emitter leads that set the proper amount of conduction prior to the injection of a signal.
   b. A.C. potentials on each lead that set the proper amount of conduction prior to the injection of a signal.
   c. D.C. potentials at the collector and base with respect to the emitter necessary to establish a transistor's conduction level.
   d. D.C. potentials on each lead that set the proper amount of resistance after a signal has been applied.

2. Which of the following illustrations shows proper biasing? (There may be more than one correct answer.)



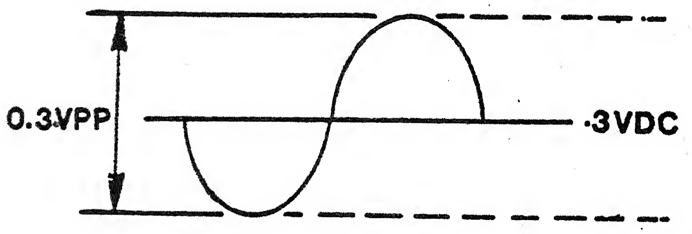
3. Which element has the most control over current flow in a three element transistor?

   a. Collector
   b. Base
   c. Emitter

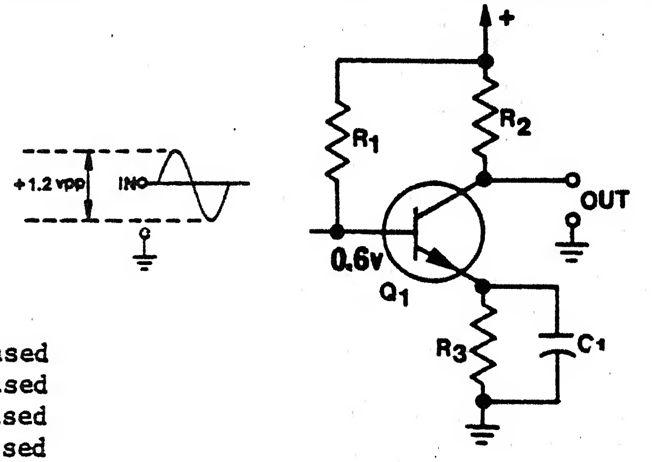
4. Dynamic bias is defined as:

   a. the varying voltage caused by an input signal on the base of a transistor which is a combination of the input signal and the static bias voltage.
   b. the DC potentials on the collector and base with respect to the emitter which establish the conduction level of a transistor.
   c. the DC difference in potential between base and emitter which establishes the conduction level of a transistor.
   d. the AC difference in potential between emitter and collector which establishes the conduction level of a transistor.

5. What potential will be on the base of a transistor when the sine wave reaches its peak negative variation? ______________________

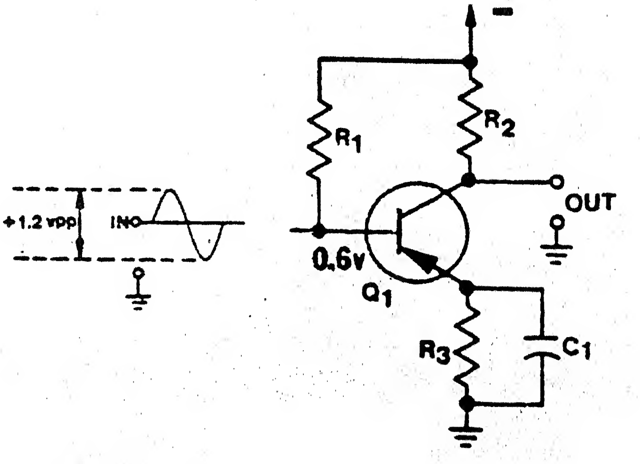


6. When a sine wave input to the base reaches its peak negative variation the NPN transistor's conductivity has __________ and the voltage across the transistor has __________ . (See the circuit illustrated below.)



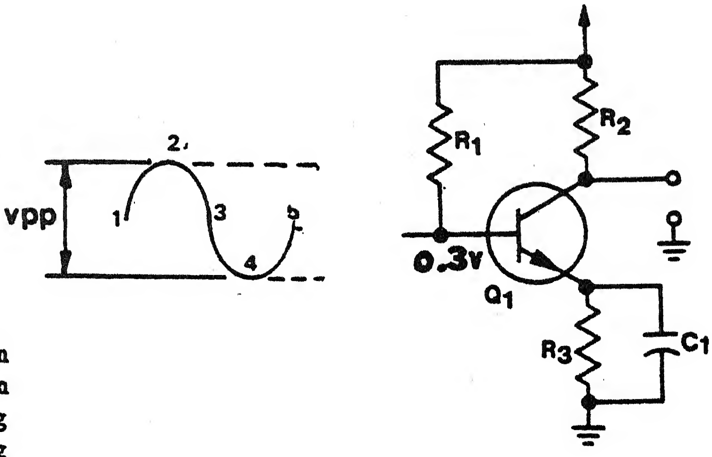
a. decreased, decreased
b. increased, increased
c. decreased, increased
d. increased, decreased

7. When a sine wave input to the base reaches its peak negative variation the PNP transistor's conductivity has __________ and the voltage across the transistor has ____________________ . (See the circuit illustrated below.)



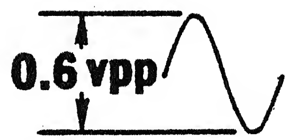
a. decreased, decreased
b. increased, increased
c. decreased, increased
d. increased, decreased

8. In the following illustration the sine wave is injected into the base of a NPN transistor. At time 4 the transistor's conduction is:

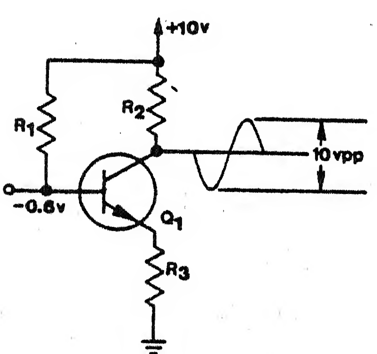


a. at maximum
b. at minimum
c. increasing
d. decreasing

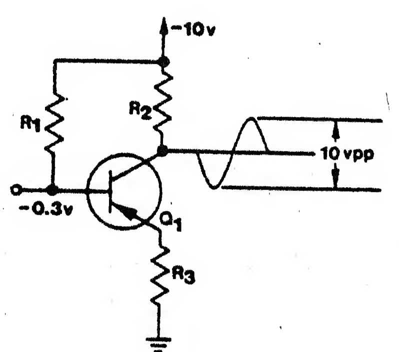
9. Which drawing illustrates correct bias and circuit operation with the input shown?



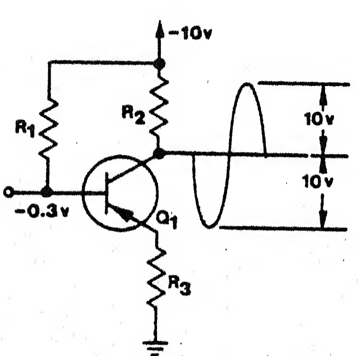
a.



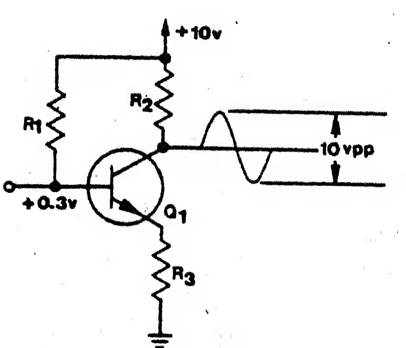
b.



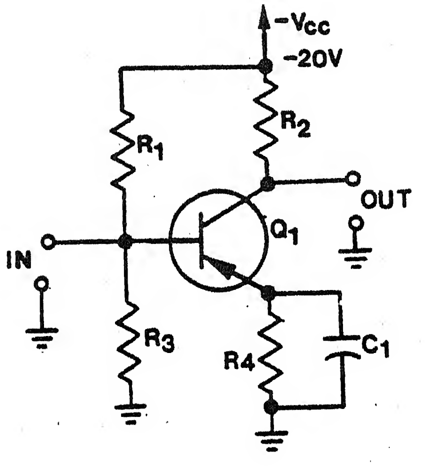
c.



d.



10. Referring to the following circuit, which of the following statements is most correct?



a. R1, R2, and R3 are stabilizing components; R1 and R3 prevent thermal runaway, R2 prevents degeneration.
b. R2, R4, and C1 are stabilizing components; R2 prevents thermal runaway, R4 and C1 prevent degeneration.
c. R3, R4, and C1 are stabilizing components; R3 and R4 prevent thermal runaway, C1 prevents degeneration.
d. R1, R3, and R4 are stabilizing components; R1 and R4 prevent thermal runaway, R3 prevents degeneration.

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

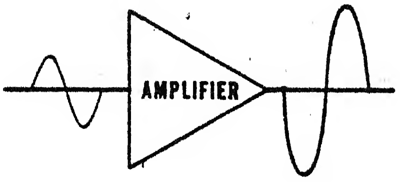
SUMMARY
LESSON III

Basic Transistor Amplifier Functional Analysis

In transistorized equipment you will come across amplifiers. The function of an amplifier is to amplify a signal; that is, make it larger. Each amplifier stage will have a certain amount of gain. The stage will provide a specific amount of amplification for any input signal within the amplifiers limits. Gain is the ratio of the amplitude of the output signal to the amplitude of the input signal.

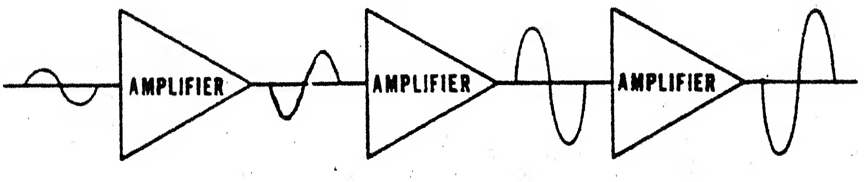
Amplifiers can be broken down into three sections. Input, output, and conversion. The input and output sections have the same function. They couple the signal to and from the amplifier stage and also block DC from the previous or following stage. Remember, capacitors and transformers can couple AC while blocking DC. The conversion section is the heart of the amplifier stage. In the single-ended type amplifier (one input and one output), the conversion section is the transistor. A small signal applied to the base of the transistor controls a larger current through the transistor.

The symbol we use to represent an amplifer is a triangle, as shown in Figure 1.



COMMON AMPLIFIER SYMBOL
Figure 1

Single-ended amplifiers connected in series are called cascade coupled. That is, the output from one amplifier is connected to the input of the next amplifier, and so on, until the desired signal strength is obtained to drive the final stage.



CASCADED AMPLIFIERS
Figure 2

There are two common types of coupling: Resistive-Capacitive (RC) and transformer. RC coupling is the most common of the two types, because RC coupling uses smaller components therefore they are less expensive, and they have a wider frequency response. RC coupling is used for voltage amplifiers with low power output. In RC coupling, the capacitor is common to both the input and the output when used as an interstage coupling device (between substages). Transformer coupling is used extensively in high power cascaded coupling. Transformer coupling is accomplished through mutual induction between primary and secondary windings.

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JOB PROGRAM
FOR
LESSON III

Basic Transistor Amplifier Functional Analysis

REFERENCES

NIDA 202 Amplifier Instruction Manual

EQUIPMENT AND MATERIALS

1. NIDA 202 Amplifier
2. PC 202-2 R-C Coupled Amplifier Card
3. Oscilloscope
4. BNC - Phone Plug Cable (1)
5. 1X Probe (2)
6. BNC - BNC Cable (1)
7. Signal Generator
8. Prefaulted R-C Coupled Amplifier Card (Obtain after Step 15)

PROCEDURE

1. Energize the signal generator and the oscilloscope. Obtain a line trace, center it, and make the following settings on the oscilloscope.

   a. VOLTS/CM - 1 Volt/Cm

   b. SWEEP FREQ Hz - TV.V

   c. SWEEP VARIABLE - Midrange

2. Remove the top cover of the NIDA 202 Amplifier.

3. Insert PC Board 202-2 into the NIDA 202 Amplifier chassis.

4. Using the BNC-PHONE Plug cable, connect the AUDIO OUT jack on the signal generator to the INPUT jack on the NIDA 202.

   a. Place mode switch to "speaker off" position.

5. Connect a 1X probe to the IN jack on the oscilloscope, and connect the other end of the 1X probe to the input jack of the 202-2 PC card. (locate this point on the schematic on page 5-5 of the NIDA 202 Instruction Manual). Energize the NIDA 202 Amplifier.

6. Adjust the signal generator for a .1 V peak to peak at 1Khz at the input to PC 202-2 as displayed on the oscilloscope.

7. Connect the 1X probe to the output of the PC 202-2 (locate this point on the schematic as well), and adjust the **VOLUME** control for a maximum undistorted output signal.

8. Observe and measure the input signal as shown on the oscilloscope. The input is ____________________ V in amplitude. Observe and measure the output signal as shown on the oscilloscope. The output is ________ V in amplitude. By comparing the input and output of PC 202-2 you can see that the signal has been _____________.

9. On the schematic locate the input section of this amplifier. The input section consists of ________, _________ and __________. Connect the 1X probe to the base of Q1-2. Notice that the input is passed through the input section with only a slight change in amplitude.

10. Locate the first conversion sub-section on the schematic of the PC 202-2. The main component of the conversion sub-section is ___________. Connect the 1X probe to the collector of Q1-2. Notice that the output signal from the conversion section is considerably larger than the input.

11. Now, using the schematic symbol for PC 202-2 locate the components comprising the output section of the first conversion sub-section (first stage of amplifier comprised of two stages, Q1-2 and Q2-2). These components are ______________ and ________________ connect the 1X probe to the base of Q2-2.

Notice that the output section operates the same as the input section, it passes the signal with a small loss of amplitude.

12. Looking at the schematic of PC 202-2, notice that the signal from the output of one amplifier stage is being fed to the ____________ of the next amplifier stage. This method of joining stages is called ______________________.

13. If there is more than one amplifier stage in an amplifier they must be coupled together in some manner. By studying the schematic you will see the sub-stages in PC 202-2 are (direct, R-C, transformer) coupled. Now, check the output of PC 202-2 by connecting the 1X probe to PIN 7. The second sub-stage/conversion section is similar to the first stage, except it's output is purely resistive coupled (R11-2 & R17); trace the output on your schematic in the Technical Manual.

14. This job program has vertified the fact that amplifiers do amplify. It has also shown you the input-conversion-output (ICO) concept is utilized within an amplifier. You were able to see R-C coupling and cascaded amplifiers in a pratical application. Although there are many things you have not seen, this job program has helped you to build a good foundation in the make-up and operation of amplifiers.

15. Now that you have observed how a good amplifier works, proceed to the progress test. Once you have completed the progress test, see your Learning Center Instructor and obtain a faulty amplifier card. Using the procedures you have previously followed, troubleshoot it to a faulty component.

16. Check with your learning Center Instructor to see if you were correct.

17. Replace all covers and return equipment to it's stowage.

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5. Connect a 1X probe to the IN jack on the oscilloscope, and connect the other end of the 1X probe to the input jack of the 202-2 PC card. (locate this point on the schematic on page 5-5 of the NIDA 202 Instruction Manual). Energize the NIDA 202 Amplifier.

6. Adjust the signal generator for a .1 V peak to peak at 1Khz at the input to PC 202-2 as displayed on the oscilloscope.

7. Connect the 1X probe to the output of the PC 202-2 (locate this point on the schematic as well), and adjust the **VOLUME** control for a maximum undistorted output signal.

8. Observe and measure the input signal as shown on the oscilloscope. The input is ____________________ V in amplitude. Observe and measure the output signal as shown on the oscilloscope. The output is ________ V in amplitude. By comparing the input and output of PC 202-2 you can see that the signal has been _____________.

9. On the schematic locate the input section of this amplifier. The input section consists of ________, _________ and ___________. Connect the 1X probe to the base of Q1-2. Notice that the input is passed through the input section with only a slight change in amplitude.

10. Locate the first conversion sub-section on the schematic of the PC 202-2. The main component of the conversion sub-section is ___________. Connect the 1X probe to the collector of Q1-2. Notice that the output signal from the conversion section is considerably larger than the input.

11. Now, using the schematic symbol for PC 202-2 locate the components comprising the output section of the first conversion sub-section (first stage of amplifier comprised of two stages, Q1-2 and Q2-2). These components are ______________ and ________________ connect the 1X probe to the base of Q2-2.

Notice that the output section operates the same as the input section, it passes the signal with a small loss of amplitude.

12. Looking at the schematic of PC 202-2, notice that the signal from the output of one amplifier stage is being fed to the ______________ of the next amplifier stage. This method of joining stages is called ________________________.

13. If there is more than one amplifier stage in an amplifier they must be coupled together in some manner. By studying the schematic you will see the sub-stages in PC 202-2 are (direct, R-C, transformer) coupled. Now, check the output of PC 202-2 by connecting the 1X probe to PIN 7. The second sub-stage/conversion section is similar to the first stage, except it's output is purely resistive coupled (R11-2 & R17); trace the output on your schematic in the Technical Manual.

14. This job program has vertified the fact that amplifiers do amplify. It has also shown you the input-conversion-output (ICO) concept is utilized within an amplifier. You were able to see R-C coupling and cascaded amplifiers in a pratical application. Although there are many things you have not seen, this job program has helped you to build a good foundation in the make-up and operation of amplifiers.

15. Now that you have observed how a good amplifier works, proceed to the progress test. Once you have completed the progress test, see your Learning Center Instructor and obtain a faulty amplifier card. Using the procedures you have previously followed, troubleshoot it to a faulty component.

16. Check with your learning Center Instructor to see if you were correct.

17. Replace all covers and return equipment to it's stowage.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANY OTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULT WITH YOUR LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONESS DO AGREE.

PROGRESS CHECK
LESSON III

Basic Transistor Amplifier Functional Analysis

1. In your own words state the function of an amplifier. ________________

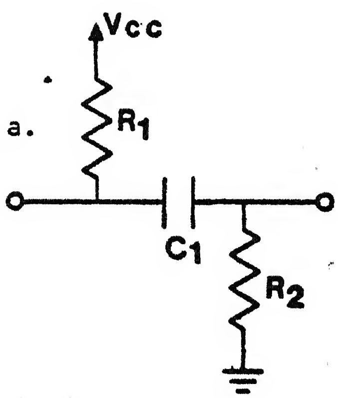
____

2. Match the proper function(s) to the sub-stage. (Some answers may require more than one letter.)

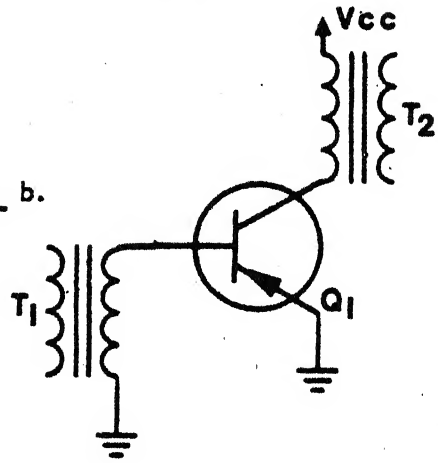
SUB-STAGE	FUNCTION
_____ 1. Input	a. Amplification
_____ 2. Conversion	b. Blocks DC between stages
_____ 3. Output	c. Couples signal

3. Label the two types of commonly used amplifier coupling circuts illustrated below.

_____ a.



_____ b.



4. Select the statement below that best describes the function of the conversion sub-stage of an amplifier.

a. Converts the DC input to an AC output.
b. Increases the strength of the signal input.
c. Supplies DC to the output stage.
d. Suppresses noise.

5. Which statement below best describes the principle of amplification in a transistor amplifier?

   a. A small input signal controls a large current flow.
   b. A small input signal increases the DC output of a transistor amplifier.
   c. A large input signal controls a small current flow.

6. If the output from an amplifier is 30ma and the input is 10 ma the current gain ratio is:

   a. 10/30 = .33
   b. 30/10 = 3
   c. 5.30 = .16
   d. 20/30 = .6

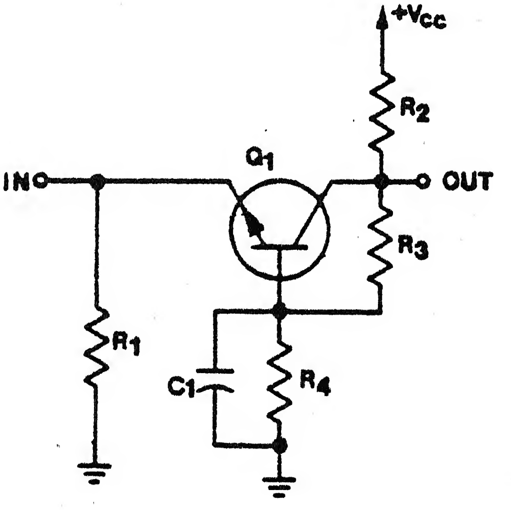
CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

SUMMARY
LESSON IV

Basic Transistor Amplifier Configurations

Amplifiers, of one kind or another, will be encountered in practically every piece of electronic equipment aboard ship. The three basic transistor amplifiers can be built by using NPN or PNP transistors.

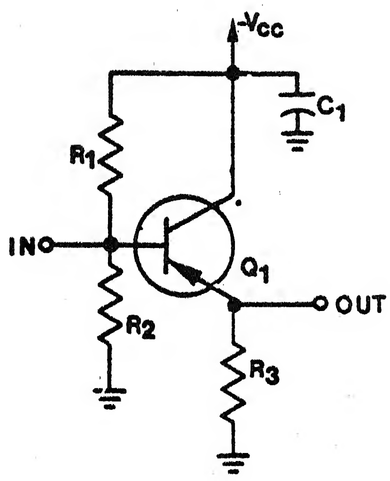
Figure 1 is a "Common Base" (CB) Amplifier.



COMMON BASE AMPLIFIER
Figure 1

The INPUT to the emitter and OUTPUT from the collector leaves the base as the common element. A high voltage gain and low current gain make the CB amplifier an ideal current control device.

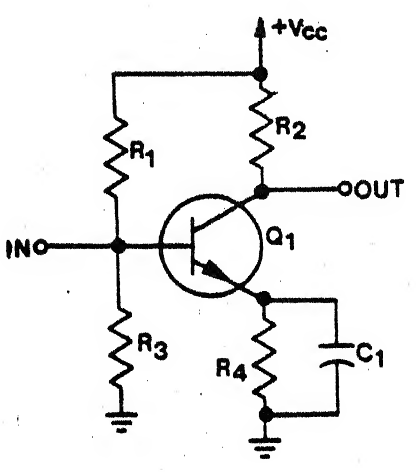
Figure 2 is a "Common Collector" (CC) amplifier.



COMMON COLLECTOR AMPLIFIER
Figure 2

The collector is the "common" element here since the input is to the base, and the output is from the emitter. High input resistance and low output resistance are the most important characteristics of this configuration since CC amplifiers are used extensively as impedance matching devices. The gain is slightly less than a 1:1 ratio.

The schematic in Figure 3 is of a typical "Common Emitter" (CE) configuration.



COMMON EMITTER AMPLIFIER
Figure 3

By observing the input and output sides of this amplifier, you can see that the emitter is the common element. Of the three types of transistor amplifiers discussed here, the CE configuration (with either the PNP or NPN transistor) is by far the most commonly used in electronics. A medium voltage and current gain provides good amplification and little distortion. The CE amplifier is the only one of the three that provides a 180° phase shift between the input and output. This condition will exist in all CE amplifiers whether an NPN or PNP transistor is used.

AT THIS POINT, YOU MAY PROCEED TO THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

JOB PROGRAM
FOR
LESSON IV

Transistor Amplifier Circuits

INTRODUCTION

In lesson IV of the study booklet you were shown different amplifier configurations and what was expected from them with certain input signals. In this job program you will see most of these circuits again. You will inject a signal into the amplifier and simultaneously measure both the input and output signals with the oscilloscope. To do this, you must use the dual trace capabilities of the oscilloscope.

SAFETY PRECAUTIONS:

Observe all standard safety precautions. There are some specific safety precautions for the NIDA 206 Amplifier. This unit has a +209 Volt DC Power Supply mounted on the chassis. This voltage may be applied to Pin 5 of the PC boards. Ensure that the HIGH VOLTAGE switch is "off" unless otherwise directed. This switch removes the +209 Volts DC from the printed circuit card jack. Do Not Remove the bottom cover of the NIDA 206 chassis. The +209 DC supply is energized any time the unit is "on" regardless of the panel switch's position.

REFERENCES

1. NIDA 206 Instruction Manual

EQUIPMENT AND MATERIALS

1. Oscilloscope (6B28)
2. Signal Generator
3. Printed circuit cards: PC206-6 Common Emitter circuit
   PC206-7 Common Collector circuit
   PC206-8 Common Base circuit
4. IX Probe (2)
5. BNC - BNC Cable (1)
6. BNC To phone plug cable (1)
7. BNC TEE Connector (1)
8. NIDA 206 Amplifier

PROCEDURE

1. Energize oscilloscope and signal generator.

2. Set up the signal generator for 1KHz audio output as follows:

   a. AN/URM-25 - MOD, XTAL & METER SELECTOR to 1000 hertz

   NOTE: The only controls needed for a 1KHz output from the AN/URM-25 are the METER SELECTOR and AUDIO OUT control. The output is taken from the AUDIO OUT jack.

   WAVETEK 186 - Frequency dial at "1", multiplier at "1K"
   GEN MODE at "cont"; WAVEFORM - NORMAL sine without offset
   GAIN and DC OFFSET - full counter clockwise
   ATTENUATION at "0", variable full clockwise

   b. Connect one end of the BNC cable to the AUDIO OUT jack or 50Ω OUT jack of the signal generator. Connect the other end to one side of the TEE connector

3. Set up the oscilloscope for dual trace operation as follows:

   a. Connect the TEE connector to the TRIGGER SOURCE jack.

   b. Set the TRIGGER SOURCE to "Ext".

   c. Set the DISPLAY MODE to "Channel 1" and obtain a line trace. Using the "Channel 1" controls set the line trace to the +1 div line on the CRT. (+1 div line is the first horizontal line above the center line.)

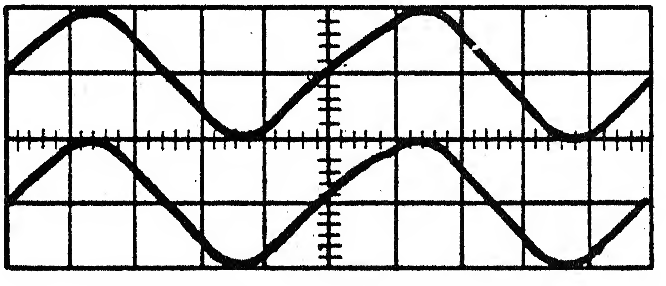
d. Set the DISPLAY MODE to "Channel 2" and obtain a line trace. Using the "Channel 2" controls set this line trace on the -1 div. horizontal line.

e. Set the DISPLAY MODE to "Chop". You are now set up for dual trace operation.

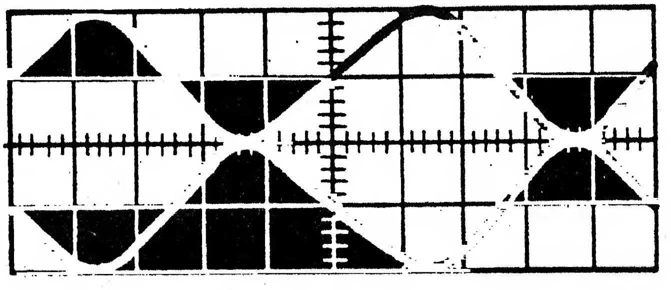
You should have two lines on the oscilloscope, one at +1 div. (Channel "1" sweep) and one at -1 div. (Channel "2" sweep). You may have to readjust the trigger controls to obtain the traces. For sensitivity and position, the Channel "1" controls will control the upper sweep and the Channel "2" controls will control the lower sweep.

When you check for phase relationship between inputs and outputs of the amplifiers you will see traces similar to the ones below.

INPUT AND OUTPUT - IN PHASE



INPUT AND OUTPUT - 180° OUT OF PHASE



4. Loosen the knurled screw on the rear of the amplifier chassis that holds the top cover. Remove the top cover by sliding the cover to the rear of the unit. Do not remove the bottom cover.

5. Ensure the HIGH VOLTAGE SWITCH on the NIDA 206 Amplifier is "off".

6. Turn the SPEAKER SWITCH located on the upper right corner of the Amplifier front panel to "off".

7. You will be working with three different amplifier circuit configurations in this job program. Refer to the schematics in the back of the NIDA 206 Technical Manual, and complete the following statements.

a. PC206-6 is common ______________ amplifier. This amplifier (will/will not) invert the input signal.

b. PC206-7 is common ______________ amplifier. This amplifier (will/will not) invert the input signal.

c. PC206-8 is a common ______________ amplifier. This amplifier (will/will not) invert the input signal.

NOTE: Perform the following steps as appropriate for one amplifier card at a time.

When you complete the procedure for PC 206-6, return to step 5 and repeat the procedure for PC206-7 and PC206-8.

8. Plug the printed circuit board PC206-6 into the amplifier at J2 and J3. Ensure the pin numbers for J2 and J3 match up with jack numbers on the PC board.

9. Using the BNC to phone plug cable, connect the BNC end to the TEE connector at the oscilloscpe external trigger input. Connect the phone plug to the input jack on the front panel of the amplifier chassis.

10. Using a 1X probe, connect Channel "1" of the oscilloscope to pin #3 of the PC Board.

11. Using the other 1X probe, connect Channel "2" of the oscilloscope to pin #7 of the PC Board.

12. Plug in and energize the NIDA 206 Amplifier.

13. Set potentiometer R17 on the Amplifier chassis (located to the left of the chassis of NIDA 206, designated bias) as follows:

a. PC206-6; R17 fully counterclockwise, then 1/4 turn clockwise.
b. PC206-7; R17 fully counterclockwise.
c. PC206-8; Position does not matter.

14. Set the AUDIO OUT control or ATTENUATION control on the signal generator for .2V peak-to-peak at the amplifier input (measured on Channel "1").

15. PC 206-6 ONLY - Check the signal at the amplifier output (Channel "2"). If the sine wave is flattened at the top, or if no sine wave is present, turn R17 slightly counterclockwise until a "clean" sine wave is obtained. If flattened at the bottom, turn R17 clockwise. If the sine wave is flattened at both top and bottom reduce the signal input to the amplifier from the signal generator — you are overdriving it.

16. Calculate the voltage gain/loss ratio and the phase relationship of input and output for the amplifier and record below:

	PC 206-6	PC 206-7	PC 206-8
a. Gain/Loss	(gain/loss)	(gain/loss)	(gain/loss)
b. Phase Inversion	(yes/no)	(yes/no)	(yes/no)
c. Ratio	______	______	______

17. Deenergize the NIDA 206 Amplifier. Go back to step 8 and repeat the procedure using PC 206-7 and PC 206-8.

18. Replace all covers and return equipment to it's stowage.

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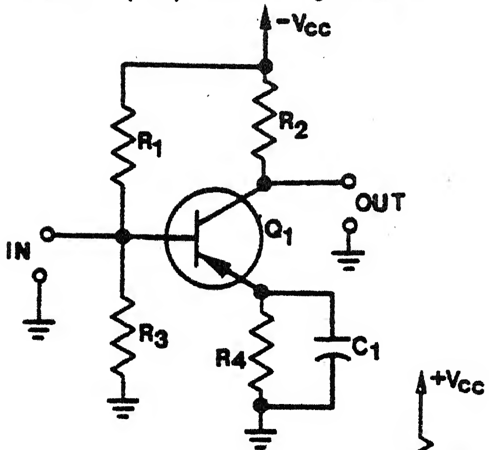
PROGRESS CHECK
LESSON IV

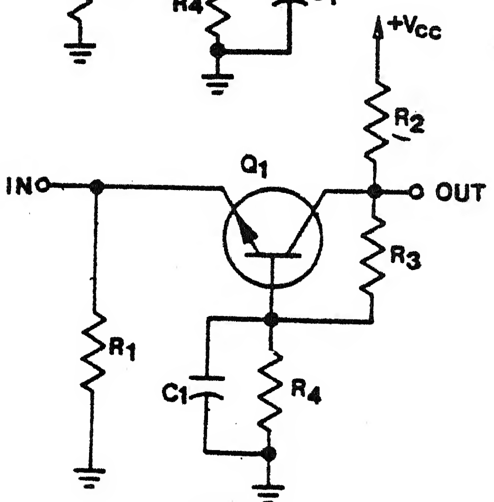
Basic Transistor Amplifier Configurations

1. Identify by labeling the circuits illustrated below:

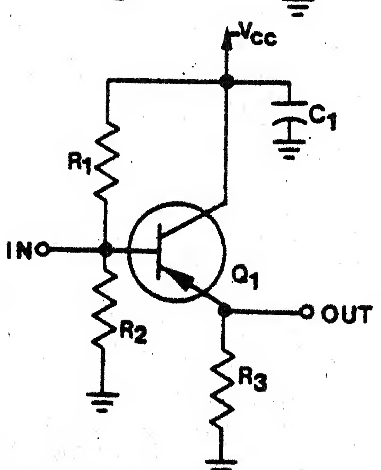
A.



B.



C.



Refer to the schematics in Question 1 to answer Questions 2, 3 & 4.

2. Schematic A has _______ of phase inversion, and a _______ current gain.

   a. 180°, medium
   b. 90°, low
   c. 270°, high
   d. 0°, high

3. Schematic B has _______ of phase inversion and a _______ current gain.

   a. 0°, low
   b. 180°, high
   c. 90°, medium
   d. 270°, low

4. Schematic C has _______ of phase inversion and a _______ current gain.

   a. 90°, low
   b. 180°, medium
   c. 270°, high
   d. 0°, high

5. Match the amplifier configuration to the amplifier function.
(Some answers may require more than one letter.)

FUNCTION	CONFIGURATION
1 Provides phase inversion	a. CB
2. Used as impedance matching device	b. CE
3. Most commonly used configuration	c. CC

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

ANSWER SHEET
FOR
JOB PROGRAM
LESSON II

Transistor Biasing

1. (-) negative
2. Yes
3. PNP
4. Increase
5. 9 volts
6. 9 volts p-p

Because of differences in training devices, readings may not be exact. However, your readings should be fairly close to those above.

ANSWER SHEET
FOR
PROGRESS CHECKS
LESSON II

Transistor Biasing

QUESTION NO.	CORRECT ANSWER
1	c
2	c, f
3	b
4	a
5	0.15v
6	c
7	d
8	b
9	b
10	c

ANSWER SHEET
FOR
JOB PROGRAM
LESSON III

Basic Transistor Amplifier Functional Analysis

8. .1v
   4.5v
   amplified

9. R1-2, C1-1 and R3-2

10. Q1-2

11. C2-2, R6-2, R8-2

12. input
    cascading

13. R-C

ANSWER SHEET
FOR
PROGRESS CHECKS
LESSON III

Basic Transistor Amplifier Functional Analysis

QUESTION NO.	CORRECT ANSWER
1	To control a large current with a small input signal (or words to that effect)
2.1	b, c
.2	a
.3	b, c
3a	Resistive-capacitive
3b	Transformer
4	b
5	a
6	b

ANSWER SHEET
FOR
JOB PROGRAM
LESSON IV

Transistorized Amplifier Circuits

7a. Common emitter amplifier, will invert the input signal.

7b. Common collector amplifier, will not invert the input signal.

7c. Common base amplifier, will not invert the input signal.

16a.	PC206-6 gain	PC206-7 loss	PC206-8 gain
16b.	yes	no	no
16c.	*56:1	1:1	*10:1

* These are minimum acceptable values

ANSWER SHEET FOR PROGRESS CHECK LESSON IV

Basic Transistor Amplifier Configurations

QUESTION NO.	CORRECT ANSWER
1a	Common-emitter
1b	Common-base
1c	Common-collector
2	a
3	a
4	d
5.1	b
5.2	c
5.3	b

NOTES